I CLAIM:

1. A method of determining characteristics of samples comprising:

a. building algorithms of the relationship between sample characteristics and absorbed and scattered light from a sample having an interior;

b. illuminating the interior of a sample with a broadband frequency spectrum;

c. detecting the spectrum of absorbed and scattered light from the sample;

d. analyzing the detected spectrum of absorbed and scattered light from the sample with the algorithms; calculating the characteristics of the sample.

2. The method of claim 1 further comprising:

a. building the algorithms to generate a regression vector that relates a VIS and NIR spectra to brix, firmness, acidity, density, pH, color and external and internal defects and disorders;

b. storing the regression vector, in a CPU having a memory, as a prediction or classification calibration algorithm;

c. illuminating the sample interior with a spectrum of 250 to 1150nm;

d. inputting the detected spectrum of absorbed and scattered light from the sample interior to a spectrometer;

e. converting the detected spectrum from analog to digital and inputting the converted spectrum to a CPU; combining the spectrum detected;

f. comparing the combined spectrum with a stored calibration algorithm;

g. predicting the characteristics of the sample.

3 The method of claim 1 further comprising:

a. the characteristics are chemical characteristics including acidity, pH and sugar content

4. The method of claim 1 further comprising:

a. the characteristics are physical characteristics including firmness, density, color, appearance and internal and external defects and disorders.

5. The method of claim 1 further comprising:

a. the characteristics are consumer characteristics.

6. The method of claim 1 further comprising:

a. sampling samples from the group of C-H, N-H or O-H chemical groups;

b. illuminating of the interior of the sample is with a frequency spectrum including visible and near infrared light;

c. building algorithms for a correlation analysis separately of Brix, firmness, ph and acidity in relation to the light spectrum output from the illuminated sample;

d. detecting the spectrum of absorbed and scattered light from the sample with a light detector.

7. The method of claim 2 further comprising:

a. illuminating of the interior of the sample with a frequency spectrum of 250 to 1150 nm;

b. detecting the spectrum of absorbed and scattered light from the sample with at least one light detector; the at least one light detector comprising at least one light detector fiber; shielding the at least one light detector fiber from the illuminating spectrum;

c. measuring the spectrum for chlorophyl at around 680 nm;

d. correlating the characteristics of Brix, firmness, pH and acidity with the measured spectrum.

8. An apparatus to predict characteristics of a sample comprising:

a. at least one broadband light source; a sample having an sample surface and an interior; input mechanism of positioning the at least one light source proximal the sample surface;

b. at least one light detector; output mechanism of positioning the at least one light detector proximal the sample surface;

c. at least one mechanism of measuring the illumination detected from the sample.

9. An apparatus of claim 8 further comprising:

a. the at least one light source produces a spectrum within the range of 250 to 1150 nm;

b. the at least one mechanism of measuring the illumination is a spectrometer; the spectrometer has at least one input;

c. the at least one light detector is a light pickup fiber; the at least one light detector collects a spectrum which is received by the at least one spectrometer input; the spectrometer has at least one spectrometer output channel; a CPU having at least one CPU input; the at least one CPU input receiving the at least one spectrometer output; at least one computer program; the CPU is controlled by the at least one computer program; the CPU having at least one CPU output; the at least one computer program causing the at least one CPU output to perform the steps of 1) calculation of absorbance spectra (173) occurs for each at least one spectrometer output channel 1...n, 2) combine absorbance spectra (174) into a single spectrum encompassing the entire wavelength range detected from the sample by spectrometers 1...n (170), 3) mathematical preprocessing or preprocess (175), by smoothing or box car smooth or calculate derivatives, precedes 4) the prediction or predict (176), for each at least one spectrometer output channel, comparing the preprocessed combined spectra (175) with at least one stored calibration spectrum or at least one calibration algorithm(s) (177) for each sample characteristic 1...x (178), comprising brix, firmness, acidity, density, pH, color and external and internal defects and disorders, for which the sample is examined, followed by 5) decisions or further

combinations and comparisons of the results of quantification of each characteristic, 1...x, comprising determination of internal and or external defects of disorders (179), (180); determination of color (181); determination of indexes of eating quality index (182), appearance quality index (183) and concluding with sorting or other decisions (184); 6) sorting or other decisions (184) may be input process controllers to control packing/sorting lines or may determine the time to harvest, time to remove from cold storage, and time to ship;

d. the sample is from the chemical group of C-H, N-O, and O-H.

10 The apparatus of claim 9 further comprising:

a. the at least one spectrometer output are converted from analog to digital by at least one A/D converter which become, for each at least one spectrometer output channel, input to at least one CPU input; the at least one CPU output provided for each at least one spectrometer output channel 1....n..

11 The apparatus of claim 8 further comprising:

a. the least one light source is a tungsten halogen lamp; the illumination is transmitted to the sample surface by fiber optics;

b. the at least one light detector is a fiber optics light pickup;

c. the at least one spectrometer comprises a 1026 linear array detector;

12 The apparatus of claim 9 further comprising:

a. the at least one light source is at least one illumination fiber.

13 The apparatus of claim 8 further comprising:

a. the at least one light source comprises a plurality of illumination fibers; b. the plurality of illumination fibers are arrayed such that each illumination fiber is equidistant from adjoining illumination fibers; the at least one light detector is positioned centrally in the array of illumination fibers.

14 The apparatus of claim 12 further comprising:

a. the at least one light source is a plurality of illumination fibers comprised of 32 illumination fibers.

15 The apparatus of claim 9 further comprising:

a. the at least one light source is a 5w tungsten halogen lamp.

16 The apparatus of claim 9 further comprising:

a. the at least one light source is a plurality of illumination sources comprised of two 50 w light sources;

b. the at least one light detector is comprised of a plurality of light detectors.

17 The apparatus of claim 15 further comprising:

a. the at least one light source is a plurality of light detectors arrayed such that each light detector is equidistant from adjoining light detectors.

18 The apparatus of claim 16 further comprising:

a. the at least one light detector is a plurality of light detectors comprising twenty-two light detectors.

19 The apparatus of claim 11 further comprising:

a. the at least one light source comprised of an ellipsoidal reflector with having a 50 w bulb with cooling fan; the at least one light source is a plurality of illumination fibers comprised of at least one fiber optic fiber for transmission of the light source to the sample surface.

b. the at least one fiber optic and the at least one light detector spring biased against the sample surface; the pressure exerted by the spring biasing limited by the character of the sample.

20 The apparatus of claim 11 further comprising:

a. the at least one light source is a 5 w tungsten halogen lamp; the at least one light detector is a single fiber optic fiber; the light source is positioned against the sample surface (180) degrees distal to the detection fiber.

21 The apparatus of claim 12 further comprising:

a. a polarization filter is positioned between the at least one light source and the sample;

b. a matching polarization filter is positioned between the at least one light detector and the sample.

22 The apparatus of claim 21 further comprising:

a. the polarization filter is a linear polarization filter; the matching polarization filter is a linear polarization filter rotated 90 degrees in relation to the polarization filter.

23 An apparatus to predict characteristics of a sample comprising:

a. at least one broadband light source; a sample having an sample surface and an interior; input mechanism of positioning the at least one light source proximal the sample surface; at least one shutter intermediate the at least one light source and the sample; the at least one light source having a lamp output;

b. at least one light detector; output mechanism of positioning the at least one light detector proximal the sample surface; at least one collimating lens intermediate the at least one light detector and the sample surface; at least one mechanism of measuring the illumination detected from the sample surface;

c. at least one reference light detector directed to the lamp output; at least one shutter intermediate the at least one reference light detector and the at least one lamp output; at least one mechanism of measuring the illumination detected from the lamp output.

24 The method of claim 2 further comprising:

a. using the predicted characteristics of the sample in combination as follows: using the ratio of the sugar content to acid content to better predict eating quality, taste, sweet/sour ratio; using the combined data from two or more of the following: sugar content, acid content, pH, firmness, color, external and internal disorders to better predict eating quality.

25 The method of claim 2 further comprising:

a. sensing sample data including sensing by sample presence sensing means the presence or absence of a sample conveyed on a sample conveyor while in motion; sensing by sample position sensing means the position/location of the sample (30) relative to the point of spectrum measurement; providing presence sensing means and position sensing means having outputs to a computer program controlled CPU; determining with the computer grogram controlled CPU if the sample 30 being measured is at the optimal location(s) for spectrum measurement; determining with the computer program controlled CPU if a sample is present.

26 The method of claim 25 further comprising:

a. a. providing a proximity sensing means for presence sensing means.

27 The method of claim 26 further comprising:

a. providing for position sensing means an encoder or pulse generator (330) detecting sample conveyor (295) movement and providing one or more electronic or digital signals to a CPU (172) which initiates, by computer program control, control signals to initiate and stop acquisition of spectra.

28 The method of claim 27 further comprising:

a. determining by computer program controlled CPU timing for performing reference testing of light source lamp, spectrometer performing of reference testing of light source lamps and of spectrometer receiving spectra input from detectors.

29 The method of claim 28 further comprising:

a. testing of reference including measurement of dark spectra and/or reference spectra and/or standard/calibration samples.

30 The method of claim 29 further comprising:

a. using a collimating lens 78 and or other light transmission means including for example fiber-optics to transfer the light that has interacted with the sample 30 to the spectrometer(s) 170 detectors 200 to achieve light source lamp light collection; making, if no sample 30 is present, other reference measurements to improve stability and accuracy including dark spectra, reference spectra (lamp intensity and color output), and standard/calibration samples, which may be optical filters or polymers or organic material with known and repeatable spectral characteristics measurements where such measurements include 1) measuring a reference spectrum (intensity vs. wavelength) of the light source(s), 2) measuring the dark current (no light conditions) of one or more spectrometer(s) 170 detector(s) 200, including but not limited to the sample spectrometer(s) 170 and the reference spectrometer(s) 170, and 3) standard or calibration samples or filters 130 or material.

31 The apparatus of claim 8 further comprising:

a. sample presence sensing means for sensing of the presence or absence of a sample conveyed on a sample conveyor while in motion; sample position sensing means of the position/location of the sample 30 relative to the point of spectrum measurement; presence sensing means and position sensing means having outputs to a computer program

controlled CPU; the computer grogram controlled CPU determining if the sample 30 being measured is at the optimal location(s) for spectrum measurement; the computer program controlled CPU determining if a sample is present.

32 The apparatus of claim 31 further comprising:

a. presence sensing means is a proximity sensing means.

33 The apparatus of claim 32 further comprising:

a. position sensing means is an encoder or pulse generator (330) detecting sample conveyor (295) movement and providing one or more electronic or digital signals to a CPU (172) which initiates, by computer program control, control signals to initiate and stop acquisition of spectra.

34 The apparatus of claim 33 further comprising:

a. computer program controlled CPU timing for performing reference testing of light source lamp, spectrometer performing of reference testing of light source lamps and of spectrometer receiving spectra input from detectors.

35 The apparatus of claim 34 further comprising:

a. reference testing including measurement of dark spectra and/or reference spectra and/or standard/calibration samples.

36 The apparatus of claim 35 further comprising:

a. light source lamp light collection achieved using a collimating lens (78) and or other light transmission means including fiber-optics to transfer the light that has interacted with the sample (30) to the spectrometer(s) (170) detectors (200); if no sample (30) is present, other reference measurements are made to improve stability and accuracy such as

previously mentioned dark spectra, reference spectra (lamp intensity and color output), and standard/calibration samples, which may be optical filters or polymers or organic material with known and repeatable spectral characteristics; measurements that are made when no sample is present include, but are not limited to 1) measuring a reference spectrum (intensity vs. wavelength) of the light source(s), 2) measuring the dark current (no light conditions) of one or more spectrometer(s) (170) detector(s) (200), including but not limited to the sample spectrometer(s) (170) and the reference spectrometer(s) (170), and 3) standard or calibration samples or filters (130) or material.

37 The method of claim 2 further comprising:

a. measuring by reference measurement changes in light source lamp intensity or color output, a reference spectrometer output and output of spectrometer receiving sample spectra input from detectors; transmitting light from light source lamps to the reference spectrometer with detector using a reference light transmission means.

38 The method of claim 37 further comprising:

a. using fiber-optics as the reference light transmission means.

39 The method of claim 37 further comprising:

a. using a light pipe as the reference light transmission means.

40 The method of claim 37 further comprising:

a. positioning the reference light transmission means, at the light source lamp, to allow only light from the light source lamp to enter the reference light transmission means.

41 The method of claim 40 further comprising:

a. placing at least one light shutter intermediate each light source lamp and each reference light transmission means; opening and closing the at least one light shutter by shutter control means.

42 The method of claim 37 further comprising:

a. measuring, by the reference spectrometer, each light source lamp separately; inputting the reference spectrometer output to the computer controlled CPU; storing in the CPU intensity vs. wavelength spectrum profile for each light source lamp; comparing the stored intensity vs. wavelength spectrum with the reference spectrometer output; determining from the comparison the condition of the light source lamp.

43 The method of claim 2 further comprising:

a. using the detected spectrum as a reference spectrum, for purposes of calculating an absorbance (or log 1/R) spectrum, which is linear with concentration.

44 The method of claim 41 further comprising:

a. closing all of the light shutters of the reference light transmission means; allowing a dark current (no light condition) measurement of the spectrometer (170) detector(s) (200); measuring the dark current and its intensity value at each wavelength (or detector) pixel; subtracting the measured dark current from a reference spectrum obtained with the shutters (330) open.

45 The method of claim 37 further comprising:

a. measuring a reference spectrometer output and a sample spectrometer output dark current; shielding by shielding means, the input to the reference spectrometer and the input to the sample spectrometer; inputting the reference spectrometer output and the sample spectrometer to the computer controlled CPU;

subtracting the output measured from the reference spectrometer; subtracting the output measured from the sample spectrometer.

46 The apparatus of claim 8 further comprising:

a. at least one light detector (80) having at least one output (82) to at least one spectrometer (170) having at least one detector (200); at least one colluminating lens (78) intermediate the at least one light detector (80) and a sample (30); the at least one light detector (80) positioned to detect light from the sample (30); at least one light source (120) lamp (123); a light shielding means intermediate the at least one light source (120) lamp (123) and a sample (30); at least one aperture (310) in the light shielding means to allow illumination of the sample (30) by the at least one light source (120) lamp (123); at least one light interruption means intermediate the at least one light source (120) lamp (123) and the at least one aperture (310); the at least one light interruption means operable by at least one light interruption control means; the at least one light interruption control means receiving control signals from at least one CPU (172) having at least one light interruption operating control output; at least one reference light transmitting means receiving reference light output from the at least one light source (120) lamp (123); at least one reference light interruption means intermediate the at least one light source (120) lamp (123) and the at least one reference light transmitting means; the at least one reference light interruption means operable by at least one reference light interruption means control means; the at least one reference light interruption means control means (305) receiving control signals from at least one CPU (172) having at least one reference light interruption operating control output (307); the at least one reference light transmitting means (81) providing an input to the at least one spectrometer (170) detector (200); the at least one CPU (172) providing at least one lamp power output (125) to the at least one light source (120) lamp (123); the at least one spectrometer (170), receiving input

from at least one reference light transmitting means (81) having at least one output (82) received as in input to the at least one CPU (172); the spectrometer output (82) capable of A/D conversion to form input to the at least one CPU (172); the at least one spectrometer (170), receiving input from at least one detector output (82) received as in input to the at least one CPU (172); the spectrometer output (82) capable of A/D conversion to form input to the at least one CPU (172); mounting means to mount light sources (120) lamps (123), detectors (80), light interruption means including shutters (300), shutter control means (305), reference light transmitting means (81) and case (250); encoder/pulse generator (330) input to CPU (172) providing sample conveyor (295) movement data; computer program to operate CPU (172) in data collection and control functions.

47 The method of 37 further comprising:

a. measuring, as a reference measurement, the light source (120) lamp(s) (123) intensity vs. wavelength output using reflecting means (360); positioning reflecting means (360) to reflect light from light source lamps to a light detector having a light detector output which is received by a spectrometer detector.

48 The method of 47 further comprising:

a. positioning the reflecting means, by reflection position means, to a position to reflect light from light source lamps to a light detector as dictated by reflecting control means (308), as an output from a CPU (172), controlling the refection position means; the CPU (172), via means, detecting the presence or absence of a sample (30) and, when a reference measurement is to be made, inserting the reflecting means as dictated by reflecting control means (308) controlling the reflection position means as an output from a computer program controlled CPU (172); withdrawing the reflecting means as dictated by reflecting control means (308)

controlling the reflection position means as an output from a computer program controlled CPU (172).

49 The apparatus of claim 8 further comprising:

a. reflecting means, positioned by reflection position means, to a position to reflect light from light source lamps to a light detector as dictated by reflecting control means (308), as an output from a CPU (172), controlling the refection position means; the CPU (172), via means, detecting the presence or absence of a sample (30) and, when a reference measurement is to be made, inserting the reflecting means as dictated by reflecting control means (308) controlling the reflection position means as an output from a computer program controlled CPU (172); withdrawing the reflecting means as dictated by reflecting control means (308) controlling the reflection position means as an output from a computer program controlled CPU (172).

50 The apparatus of claim 8 further comprising:

a. a light reflecting or diffusing body for obtaining the reference spectrum may also be obtained by mechanical insertion of reference means (430) in or near the location where actual sample (30) is normally measured, which is between the light source (120) lamp(s) (123) and reference light transmission means (320) leading to the sample spectrometer (170) detector (200)(s); insertion is by insertion means including but not limited to an actuator system (400) capable, upon receiving control signals or means as recognized by those of ordinary skill including control signals or means provided from a CPU (172), of operation of an actuator (410) causing a piston (420) to extend (421) and retract (422); power, including electrical, pneumatic, hydraulic and other means, is provided to operate the actuator by power transmission means (440).

51 The method of claim 2 further comprising:

a. illuminating, with at least one light source lamp, the sample interior while the sample is rolling or revolving, where a rolling measurement generally improving whole product measurement.

52 The method of claim 2 further comprising:

a. illuminating, with at least one light source lamp, the sample interior while the sample is not rolling or revolving, where a non-rolling measurement provides better accuracy and introduces less spectral noise due to movement.

53 The method of claim 2 further comprising:

a. obtaining, as a sample (30) passes by the point of spectrum acquisition, multiple spectra, where each spectrum representing a different measurement location or area on the product.

54 The method of claim 2 further comprising:

a. optimizing signal-to-noise and accuracy with small and large samples by 1) determining the size or weight of the sample by weight or mass sensors common to the industry; 2) utilizing a color sorter or defect sorter to provide data; 3) utilizing other size sensors based on magnetic, inductive, light reflectance or multiple light beam curtains, common to other industries.

55 The method of claim 54 further comprising:

a. adjusting, in accordance with the relative size of the sample, the hardware spectrum acquisition parameters or the amount of light, to provide an improved signal-to-noise ratio spectrum for large samples (30) and/or to prevent detector (80) saturation by light for small product sample (30).

56 The method of claim 2 further comprising:

a. improving accuracy by inspection of multiple individual spectra collected from a single sample; removing poor quality or "outlier" spectra; calculating the absorbance spectrum from the raw data collected for dark, reference and sample; inspecting each individual spectrum from the series or batch of spectra acquired for each individual product sample by a computer program controlled CPU or by programmed hardware; deleting poor quality spectra from this batch of spectra, using the remaining spectra for constituent or property prediction; combining the retained spectra of the product sample with the appropriate reference and dark current measurements to produce an absorbance spectrum as follows: absorbance spectrum = -log10 [(sample intensity spectrum- sample dark current spectrum) / (reference intensity spectrum – reference dark current spectrum)] i.e. the absorbance spectrum is equal to the negative logarithm (base 10) of the ratio of the dark current corrected sample spectrum to the dark current corrected reference spectrum.

57 The method of claim 56 further comprising:

a. combining all of the absorbance spectra for each product sample to produce a mean or average absorbance spectrum of the product sample; using this average absorbance spectra to compute the sample component, characteristic or property of interest based on a previously stored calibration algorithm.

58 The method of claim 56 further comprising:

a. using each absorbance spectrum individually with the previously stored calibration algorithm to compute multiple results of the sample component, characteristic or property of interest for an individual product sample; determining the average or mean component, characteristic or property of interest by summing all

of the values and dividing the resultant sum by the number of absorbance spectra used.

59 The method of claim 2 further comprising:

a. measuring samples and linking location on product sample where visible/NIR data was collected with the same location that will be measured by the laboratory reference technique; calibrating performed as follows: 1) measuring spectra of product sample (30) and measuring absorbance spectra; correcting for reference and dark current and storing measurements; 2) undertaking standard laboratory measurements on the product sample (30); observing that it is important to the success of the NIR method that the portion of the sample (30) that is interrogated between the light source(s) (120) lamps (123) and light collection(s) detectors (80), leading to the spectrometer(s) (170) detectors (200) is the same as that portion measured by the standard laboratory technique.

60 The method of claim 59 further comprising:

a. transporting samples, by a sample conveyors (295), to the NIR measurement location including to a light detector; selecting rolling or not rolling sample conveyor (295) means; where rolling analyzing the entire sample for the component, characteristic or property of interest; averaging, if calibration algorithms are constructed in this way (using measurements of rolling product), all of the retained spectra for that individual product to produce an average absorbance spectrum and the total product component or property is assigned to this one absorbance spectrum.

61 The method of claim 59 further comprising:

a. transporting samples, by a sample conveyor (295), to the NIR measurement location including to a light detector; selection not rolling sample conveyor (295) means; performing laboratory measurements on the same portion of product sample (30) that spectra were taken from; determining whether to separate a sample into smaller sub-portions prior to laboratory analysis; adjusting the time period of NIR data acquisition to shorter or longer times, corresponding to the measurement of smaller or larger product samples (30), respectively; associating, with each sub-portion of the product sample (30), one or more spectra associated with that particular location; assigning the laboratory determined component, characteristic or property of interest to each spectrum or spectra from that particular location.

62 The method of claim 2 further comprising:

a. preforming mathematical processing on absorbance spectra prior to conducting statistical correlation analysis and calibration model building; pre-processing absorbance spectra using a bin and smooth function; relating by Partial least squares analysis (or variants thereof such as piecewise direct standardization) the processed absorbance spectrum to the assigned component and property values such as Brix, acidity, pH, firmness, color, internal or external disorder severity and type, and eating quality.

63 The method of claim 2 further comprising:

a. minimizing the number of samples needed to develop a calibration model; collecting spectra on all test samples; performing, prior to destructive laboratory measurements, principal components analysis (PCA) on the absorbance spectra; generating Resultant Score plots from PCA; selecting a subset of the original samples from the Score plots in either a random fashion or by selecting samples that, as a

group, yield a similar range, mean and standard deviation of score values compared to the entire group of original samples (30).

64 The method of claim 63 further comprising:

a. periodically requiring calibration updates to maintain measurement accuracy; minimizing the efforts of calibration updates; analyzing, as fruit or vegetable samples are in a packing and sorting warehouse, the visible/near infrared spectra; examining by computer program controlled CPU, and determining if the sample qualifies as a potential calibration update sample; selecting calibration update samples (30) which cover low to high component values and which have Score values that cover the same range as the original sample's (30) Score values.